Electronic Imaging Standards for Archiving Records

Volume I

May 31, 1997

This document was prepared by a contract team from Logicon Communications Technology Group as the product of the Deputy Assistant Secretary of Defense, Information Management. The project was aided by two workshops (October 30-31, 1996 and March 4-6, 1997) facilitated by the Operational Process Improvement Office of the Defense Information Services Agency. The project was accomplished at the Logicon offices, Sequoia Plaza, Arlington, Virginia. Logicon is performing this task under DISA/JIEO/D613 contract number DAAB07-91-D-B519 and TO 1820-04-007.

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1. DOCUMENT DESCRIPTION

a. TYPE	b. TITLE
Report	Electronic Imaging Standards for Archiving Records
c. PAGE COUNT	**d. SUBJECT AREA**
46	Graphics Information Standards

2. AUTHOR/SPEAKER

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d. OFFICE	**e. AGENCY**	
OASD(C3I) ODASD(C3) IT	DoD (Office of the Secretary of Defense	

3. PRESENTATION/PUBLICATION DATA *(Date, Place, Event)*

This is a technical report we would like to distribute to the public and make available on the Internet on our C3I Records Management homepage.

4. POINT OF CONTACT

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6. REMARKS

This report was developed under contract support by Logicon with government, industry and academia participation. Mr. Newlin was the COTR for this contract task. DoD plans to present this report to the National Archives and Records Administration once it is approved for release by OASD Public Affairs.

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Teresa G. Meyer	970610

DD Form 1910, AUG 90 (EG) *Previous edition may be used.* Designed using Perform Pro, WHS/DIOR, Oct 94

97-S-2203

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	May 31, 1997	Final Report

4. TITLE AND SUBTITLE
Electronic Imaging Standards for Archiving Records

5. FUNDING NUMBERS
C - DAAB07-91-D-B519
TA - TO 1820-04-007

DISA/JIEO/D613

6. AUTHOR(S)
Logicon Communications Technology Group
for Deputy Assistant Secretary of Defense, Information Management

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Logicon Communications Technology Group
Sequoia Plaza
Arlington, VA

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
OASD(C3I)ODASD(C3)IT
6000 Defense Pentagon
Washington, D. C. 20301-6000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
97-S-2263

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION AVAILABILITY STATEMENT
Available in hard copy.

12b. DISTRIBUTION CODE
General Distribution
NTIS

13. ABSTRACT *(Maximum 200 words)*

Purpose: Requirements analysis for electronic records recording formats that will lead to the selection of alternative standards for the storage and retrieval of electronic records and the information they contain. Content: First report to provide information on image standards agencies with which the Department of Defense should participate in order to assure the needs of the Department are addressed by emerging standards. Selection criteria used in narrowing the standards considered are included. Recommendation made to the National Archives of SGML as a format in which to preserve images of historical value. Limitations of SGML. Further study required.

14. SUBJECT TERMS
Electronic Imagery Records Usage, Storage, National Archives and Records Administration, Imagery Standards

15. NUMBER OF PAGES
46

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

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Preface

As Executive agent for the Department of Defense (DoD) the Office of the Assistant Secretary of Defense (Command, Control, Communications and Intelligence) requires continued technical assistance in support of Functional Process Improvements within the Department. It tasked Logicon to conduct a requirements analysis for electronic records recording standards that will lead to selection of alternative standards for the storage and retrieval of electronic records. This is in support of 44 United States Code (USC) and 36 Code of Federal Regulations (CFR) requirements for storage of electronic records with the National Archives and Records Administration (NARA).

This report includes the sections listed below. Section 1.0, "Introduction," provides a synopsis of the purpose and authority for this report. Section 2.0, "Background," arranges the history and current status of archiving electronic records. Section 3.0, "National Archives and Records Administration," describes key issues relating to the organization receiving archived records. Section 4.0 "DoD and Electronic Imagery Records Usage," depicts the evolution of imagery records usage and the needs for standards. Section 5.0 "DoD and Electronics Records Storage," explains how DoD and other entities store electronic records, emphasizing images. Section 6.0 "Specific Standards Issues Discussed at Workshop" analyzes requirements for imaging standards and methods discussed by subject matter experts at two groupware workshops. Section 7.0 "Imagery Standards Bodies and DoD Participation," presents the standards bodies or similar organizations DoD should work with in setting up de jure or de facto standards. Section 8.0 "Imagery Standards Issues," discusses direction for DoD and difficulties with imagery standards in archiving. Section 9.0 "Recommended Imagery Standards," presents the results of the analysis, listing the recommended formats, suggesting directions for the future of digital imagery archiving. Section 10.0 "Conclusion," offers the conclusions of the study and suggests future directions and research needs. Volume II contains appendices with corroborating or background material.

Executive Summary

The purpose of this report was to conduct a requirements analysis for electronic records recording formats that will lead to the selection of alternative standards for the storage and retrieval of electronic records and the information they contain. Using two workshops as the basis for the source material, the study reflects the considerable progress made in that direction. Criteria were applied, some solutions found, and directions to follow to resolve the remainder established.

Specifically, Image Standards Agencies the Department of Defense should participate with are identified. Additionally, DoD is advised to pursue relationships with commercial producers. As more products are purchased commercial-off-the-shelf, the Department should, as a customer, work with its providers. This means contacting organizations such as Adobe to explain how DoD might benefit from improvements to PDF, or deal with the consortium developing FlashPix, to share needs before the specifications are complete.

The selection criteria established by the group narrowed the assemblage of standards to consider to less than a dozen. None of this dozen were immediately eliminated from consideration, because they need further research. One, SGML, should be accepted by the National Archives and the Department. The caveat is that DoD organizations now using SGML should be allowed to preserve and deliver to NARA their data in this format. The high cost of taking documents into this format makes it ineffective as a device for storing all archives. For example, storing the one billion pages subject to imaging and redaction in an ongoing declassification effort could cost as much as $4,750,000,000, an impossible figure to justify in the budget.

To complete this study, the department needs to

- Determine the life cycle costs of using each potential standard and plan methods for the inclusion of this figure in the DoD budget.
- Survey organizations to determine volume and formats of images
- Assemble a team of experts to include new profiles, standards, conformance testing and certification efforts, test suite generation and promulgation efforts, and joint industry and government initiatives.
- Complete the evaluation of existing standards using the workshop criteria
- Update and revise affected DoD publications as required
- As technology advances, review the imagery policies and standards and update on a periodic basis
- Evaluate the need for a DoD digital library allowing access to and less costly preservation of data prior to archiving with NARA

Taking this project to its next logical steps will provide DoD with a way to follow the instructions of archiving laws while offering greater access to digital information.

1.0 INTRODUCTION

Purpose. The purpose of this report is to conduct a requirements analysis for electronic records recording formats that will lead to the selection of alternative standards for the storage and retrieval of electronic records and the information they contain. The requirements analysis included a survey of formats being used across the Department of Defense (DoD), Library of Congress, National Archives and Records Administration (NARA) and other entities. Using a groupware workshop technique involving a diverse group of subject matter experts, the team reviewed the requirements of NARA, and found that methods already existed to store text materials. No method existed to store electronic images, and images make up, by volume, the majority of DoD accessions to NARA. As a result guidance from the sponsoring agency focused the research and analysis on imagery standards DoD should recommend to NARA for acceptance in archiving DoD image records.

This report documents and recommends a set of imaging standards to consider in archiving electronic imagery records. In this information age, more records are being made available as images. The major types of images fall into four categories of business, technical, personnel, and medical. These include spreadsheets, drawings, forms, pictures, weather, satellite images, models and simulation, video, television, multimedia, finger prints, x-rays, MRI, CAT Scans, EKG's and images of pages of text. The DoD has the majority of the records at National Archives and Records Administration (NARA), but NARA has no standards for imagery information. Currently the NARA only accepts electronic records in the American Standard Code for Information Interchange (ASCII) and Extended Binary Coded Decimal Interchange Code (EBCDIC) formats and on magnetic tapes or CD-ROM. These two standards only address the formats for electronic text materials. The objective of this analysis was to improve information systems by identifying and recommending an alternative set of storage and retrieval standards for electronic imagery records information.

Workshops. Two groupware workshop sessions were held with representatives from DoD, Federal Government, Industry and Academe. (See Appendix B) These workshops identified and documented DoD's major imagery records requirements and proposed a minimum set of imagery standards supported by the market place that will be acceptable to both DoD and NARA for long term imaging archiving as the imaging technology evolves. This report summarizes the findings and recommendations of the participants and experts that attended these workshops. The findings identify for NARA the specific image standards requirements that will increase efficiency, effectiveness and usefulness of archival information. They also identify the commercial standards that could satisfy requirements and they identify technical imagery standards bodies that the government should participate with in developing the requirements needed by the Department of Defense and NARA.

2.0 BACKGROUND

From ancient times people have maintained an image and textual record of their condition and their progress. Over the past two thousand years little varied in the reasons for preserving information or the types of records stored: theological, government, personal, business, scientific and academic research all needed safe and accessible storage. Old issues of selection (accession), medium of storage, security, authenticity of the information, ownership, accessibility, standardization, loss of data or information, and cost, are still issues. Some conventions and methods of storing this information changed over the years -- to suit the occasion or times; maps on goatskins, paper, clay, brass, or even silk: different methods of painting evolved. New technologies propelled new methods such as film, movies, phonograph records, sound and video tapes, television, and computers to share and store information. (See Figure 1)

Preserving The Human Record - Selected Times

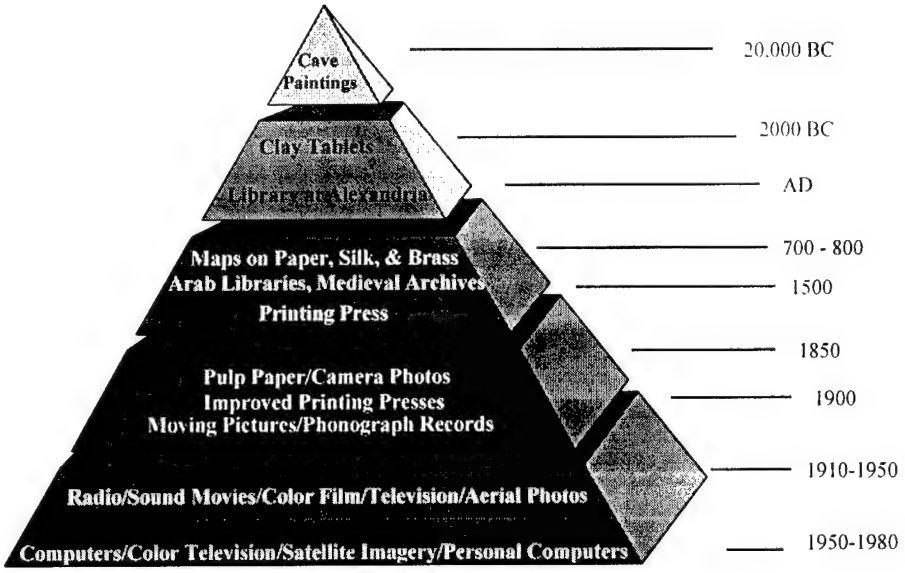


Figure 1. Archives - Some Significant Dates

Digital Challenge. The advent of the computer significantly altered the pace of change. This challenges people interested in creating standards and preserving records. (See Figure 2)

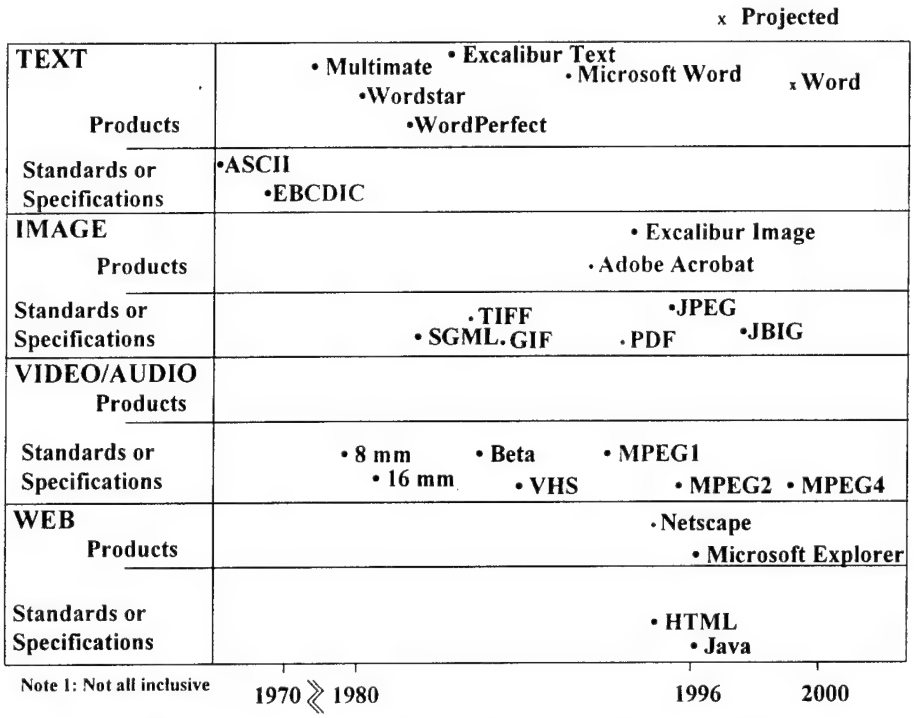


Figure 2, Timeline for Development of Selected Imaging Standards and Products. For definitions of acronyms see Chapter 5.

In the past, preserved items were generally visible and storage methods altered slowly. For example, a book properly accessioned, cataloged, and stored could reside unaltered in the archives, even if well used, for over a century. Standards applied, such as use of alphabets, pagination, or placement of text, could vary slightly without creating problems. A researcher may have no difficulty reading a 200 year old document. Electronic records pose more storage challenges. Formats often vary with great speed. As an example, take a word processed text stored in WordStar on a 5 1/4 inch disk in 1987. First, in 1997, very few sources can still read the WordStar format. Second, the percentage of 5 1/4 disk compatible computers decreased. Both the format and the technology changed markedly in the past ten years. For electronic images, the rate of change was even faster.

> In a meeting sponsored by the Australian Archives, scholar Maggie Exon said, "Unfortunately, as we know, digital materials do provide particular problems for preservation. There is a very real possibility that *nothing* created, stored, and disseminated electronically will survive in the long term. The problem does need to be stated this dramatically. I have an unfailing sinking feeling whenever anybody links the concepts of digitization and preservation. I have a profound and unchanging disbelief that these two concepts belong in any sense in the same world."[1]

The challenge is to preserve and maintain electronic records in a usable form, particularly in the case of graphic images.

3.0 NATIONAL ARCHIVES AND RECORDS ADMINISTRATION

The National Archives and Records Administration (NARA), an independent federal agency, acquires, preserves, and makes available for research records of enduring value created or received by organizations of the executive, legislative, and judicial branches of the Federal Government. (For some specific legal requirements, see Appendix F) NARA's 33 facilities that store this information house about 21.5 million cubic feet of original textual materials -- about the equivalent of 4 billion pages of text. The multimedia collections contain nearly 300,000 reels of motion picture film, more than 5 million maps, charts and architectural drawings, more than 200,000 sound and video recordings, more than 9 million aerial photographs, nearly 14 million still pictures and posters, and about 29,000 computer data sets.[2] The archives also have over 300,000 roles of microfilm.[3] These records covered the period from the Continental Congress to 1994 and a wide range of topics including policy, civilian and military personnel records.

DoD Relationship. The Department of Defense is the largest single contributor to the archives and deposits records in text, audio-visual, electronic and other formats. The largest single area by sheer volume involves imagery -- photographs, films, engineering drawings, blueprints, and other such records. The volume of transfers varies by year and depends on the world order -- for example the records for World War II greatly exceed the total for the preceding twenty years. With the passage of time and changing technology the types of items retained has also varied. The importance of these records is apparent in their use in many documentaries, in research, and their continued use for training and in reviewing current policy and plans. An example of the widespread need for these files is the 1,500,000 requests annually for information on veterans records.

To get an idea of the current requirements this project surveyed the accessions to NARA from DoD from fiscal year 1993 through fiscal year 1996. DoD transferred over 36,000 cubic feet of textual records, 1500 cubic feet of audio-visual materials, 60,000 cubic feet of aerial photographs, 4,000 cubic feet of other photographic images and drawings in traditional media. The electronic records collection included 7,800,000 records from the Army Surgeon General, Southeast Asia Combat Area Casualty Files, contract data, and several database records. [4] (See Appendix E)

For the Department of Defense, the process of transferring records to the Archives is fairly clear. Records managers at DoD and archivists at NARA agree on a schedule for the records. Under these schedules, and the General Records Schedules that apply to all Federal Agencies, DoD and NARA establish retention periods for all DoD records. At prescribed time periods managers destroy some records on-site, transfer others to the appropriate Federal Records Center (FRC) for long-term storage, and transfer a small portion to the National Archives for permanent retention either directly from DoD facilities or after a period of time in an FRC. Because of preservation concerns, NARA accessions electronic records directly from DoD facilities. (See Figure 3)

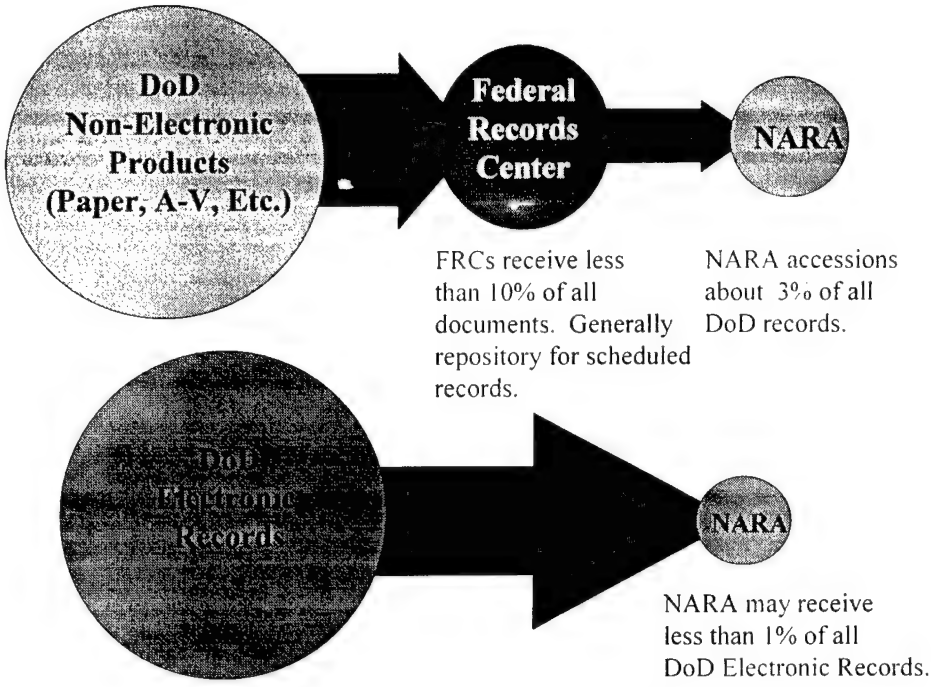
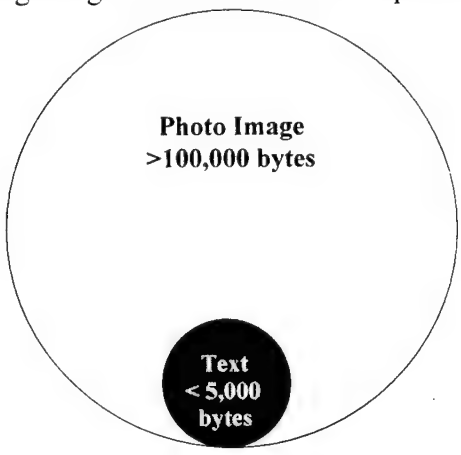


Figure 3. Movement of Records from DoD to NARA.

Future Access. To ensure future access to electronic records, NARA has required that all such records must conform with national and international encoding and recording standards. Currently NARA requires that all electronic records adhere to either the American Standard Code for Information Interchange (ASCII) or Extended Binary Coded Decimal Interchange Code (EBCDIC) format and be stored on tape or CD-ROM. This system fails to address images, the majority of non-digital accessions (by volume) from DoD. An added problem is that digital images take up a great deal more computer memory space than comparable text. (See Figure 4) Because of this difficulty with storing images and their relative importance, they became the focus of this study.



Text and Image digital space requirements for equivalent to one 8 1/2" x 11" page.

Figure 4. Storage Space Requirements

NARA's Challenges. NARA's task of preserving electronic records is expanding rapidly. Likewise the complexity and costs associated with this task lead several sources in America, including NARA leaders, to question the ability of the National Archives to store required electronic records at current funding levels. The task confronting them is daunting, to save all important records, yet to

do so only in formats that can easily migrate from an old format to a new one, probably every five to ten years. Preservation and storage of electronic records evolved into one of the most expensive portions of the records life cycle. In the paper world, the costs of storage are usually greatest at accession -- the physical accessioning, the cataloging, the storage location, are all up front costs. Once the object is in place the costs are fairly steady and known. John Carlin, Archivist of the United States, in NARA's Strategic Plan noted that just the cost of storing paper records consumes almost half of NARA's annual budget. This leaves insufficient money to take care of needed major facility repairs or the additional space needed. He also noted the problems of the "PROFS case," in which courts required the archives to store White House e-mail and electronic records, yet which were unfunded in the budget.[5] Looking at the NARA budget a National Research Council report discussing the archiving of scientific records even went so far as to say, "NARA's budget for the Center for Electronic Records, which has the formal responsibility for archiving all types of federal electronic records, was only $2.5 million in FY 1994, a budget lower than that of many of the individual agency data centers ..... Given NARA's current and projected level of effort for archiving electronic scientific data, it is obvious that NARA will be unable to take custody of the vast majority of these scientific data sets."[6] Though DoD does not wish to be an archiving agency, it must look at this issue and consider at least temporary methods to use until NARA can assume the full responsibility for archiving electronic records. Recognizing the primacy of the National Archives in deciding archival matters, such decisions should be made in concert with NARA's Center for Electronic Records.

4.0 DOD AND ELECTRONIC IMAGERY RECORDS USAGE

Core Missions. While NARA's core mission is to preserve records and provide access to them. the core mission of the Department of Defense is warfighting. (See Figure 5)

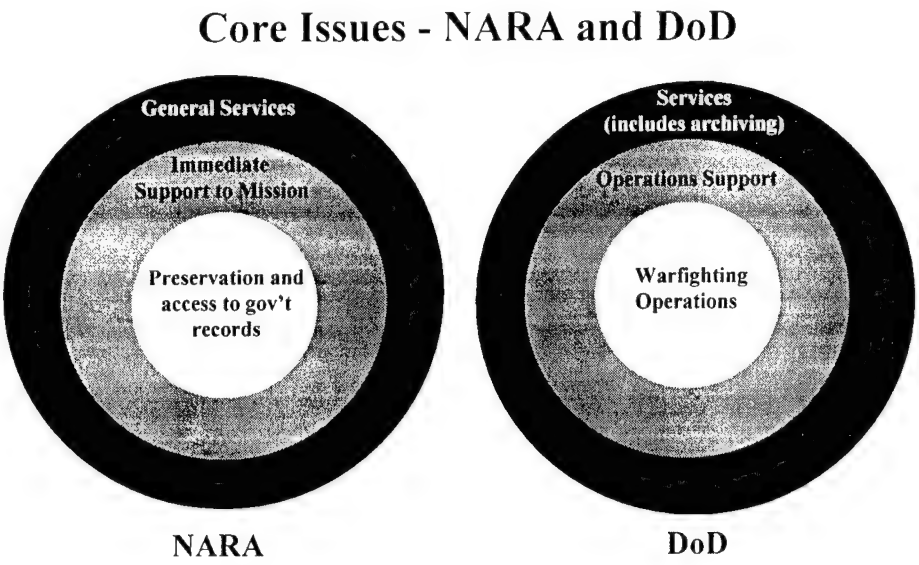


Figure 5. Core Organizational Issues for NARA and DoD

Because of this focus DoD programmers and users tend to view digital information in terms of enhancing mission effectiveness. This operational viewpoint largely precluded concern with long term preservation. The Department leadership readily accepts the need for preservation and has routinely cooperated with NARA in this regard. In addition to being the law, it remains in the department's own interest, for the archived materials provide continuity information, training materials, and research sources on how to better conduct war. Still, because of the organizational priorities, those developing or gathering digital data rarely focus on preservation, nor should they. The operational side of needs always comes first. Still, where practical, the department wants the ability to retain access to data.

DoD Concerns. Several examples of the operational concern exist in DoD. One is the push by DoD Components to achieve equipment interoperability. At individual facilities information mangers attempt to minimize "stovepiping," or the creation of databases that can not communicate with one another.

In this setting one of the significant changes of recent years is the significant increase in the use of digitized imagery. Operationally, many examples are of day to day use, but would not be archived. Other items, like the dramatic Joint Surveillance Target Attack Radar System (J-STARS) images depicting the "Highway of Death" during the Persian Gulf War deserve preser...on. To understand all the development of the battles and war, digital battle orders and directives require capture.

On the technical side, the engineering drawings increasingly rely on the computer monitor instead of the drafting table. Some computer programs even allow three dimensional viewing. Service directives require retention of engineering drawings of ships for their life. This requirement remains for digital drawings. This at a time when it is not unusual for the armed forces to retain ships and aircraft for thirty or even forty years. Personnel offices digitally store images of fingerprints. Medical records managers must preserve digital MRIs, CAT Scans, or even x-rays of service members. The National Imagery and Mapping Agency (NIMA, the successor to the Defense Mapping Agency) increasingly digitizes geographical information systems (GIS) data. Digital enhancement of photos can produce better images than the original, and these images often deserve preservation. Retention of this information is valuable to the Services.

Related to this, the Department of Defense must complete an interesting legacy by the year 2000. That is to declassify almost one billion pages of documents. This is the equivalent of six hundred stacks of paper piled to the height of the Washington monument. A rather daunting task, this involves making images of the original pages and redacting them (blacking out the items still classified). Traditionally done with paper, the Department plans to digitally scan the images using a TIFF specification. In this instance the storage now involves the original page and a digital image. This greatly speeds up the process and saves money.

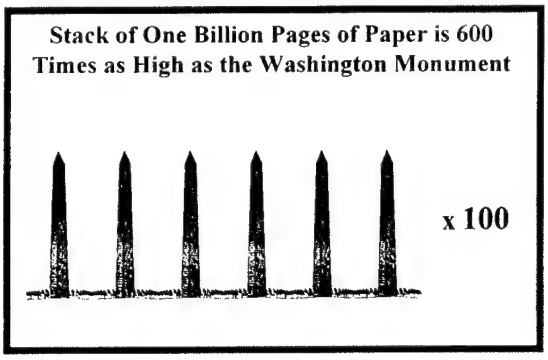


Figure 6: Amount of Paper in Declassification Project

Production of these images is possible because of specific standards implemented to allow their creation. Within the Department of Defense, requirements exist to go beyond international standards, to meet specific DoD criteria designed to minimize duplication and to enhance interoperability.

Why Standards Evolved. Standards in most disciplines developed over time in response to a need for uniformity. Examples of this are standards for screw threads and for electrical power. Standards work in the information technology field has only recently begun, with most of the work in the last ten years. Standards for Fax machines and VCRs are examples of standards created in response to the development of a new technology.

The proliferation of computers and the rate of change of technology has caused major problems for the standards bodies. Some estimates indicate that more than 50 percent of all new standards pages being developed these days are in the field of information technology. In this rapidly changing field, timing is critical to the success of a standard.

Pushing a standard too early entails the risk of entrenching an approach or technology that does not meet real-world needs. Creating standards that do not serve commercial interests slows down the growth of the entire industry. On the other hand, standardizing too late causes arbitrary diversity and wasted investment.

At the workshop, Steve Carson noted the key results or benefits of standardization are:

- Enhanced product quality and reliability at a reasonable price
- Improved health, safety and environmental protection, and reduction of waste
- Greater compatibility and interoperability of goods and services, giving the purchaser more flexibility in equipment selection and use
- Simplification for improved usability
- Reduction in the number of models, and thus reduction in costs
- Increased distribution efficiency, and ease of maintenance
- Increased assurance that there will be a large market for a particular piece of equipment or software

The principal disadvantage of standards is their tendency to freeze technology. In the time it takes to develop, subject to review and compromise, and promulgate a new standard, more efficient or new technologies may appear.

How do Standards Map to Where We Are Going

The standards considered in the group session, SGML, PDF, TIFF, HTML and others, were all designed and developed to interchange operational graphics. While some such products are in the developmental stage, we have not found any standards or products specifically designed for the archiving of records.

The group discussed a great number of different documents that could possibly be candidates for storage by NARA. These documents include redacted declassified documents, Defense Intelligence Agency (DIA) images, GIS documents, and medical records. To store this vast array of images, no single standard could fulfill all the requirements.

Standards Bodies and Associated Products

The major formal organizations which develop or facilitate the development of standards for information processing are: the International Organization for Standardization (ISO), the American National Standards Institute (ANSI), the Institute for Electrical and Electronic Engineers (IEEE), the International Telecommunications Union (ITU), and the Internet Society (ISOC) which includes the Internet Architecture Board (IAB) and the Internet Engineering Task Force (IETF).

Informal standards are developed by either single companies (Microsoft's RTF), an alliance of a few companies (TIFF developed by Microsoft, Aldus, and Hewlett-Packard), or a consortia of many vendors (the Open Software Foundation's Distributed Computing

Environment). These standards developers have no formal accreditation and release their products into the public domain.

A de facto (informal) standard emerges from popular use of a technology, but accredited standards organizations create de jure (formal) standards. A technology becomes a de facto standard in the industry by "popular vote," the purchase of one product over all competing products. The "winning" standard may reflect a compromise of competing standards and may not be the most technologically superior. By achieving greater market penetration, VHS became the standard for video cassette recorders, even though many considered BETA to be the better product. Table 1 shows some of the formal and informal standards related to the archiving of electronic images. (See Appendix A for a description of each of the standards and standards organizations.)

Table 1. Formal and Informal Standards

Type	Sponsor	Standard
Formal	ISO	SGML, JPEG, MPEG, CGM
	ITU	Group 3 and Group 4 fax
	IAB	HTML
Informal	Microsoft, Aldus, HP	TIFF
	CompuServe	GIF
	Adobe	PDF

DoD Guidance on Standards

DII - The Defense Information Infrastructure (DII) encompasses all DoD shared resources (hardware and software) that make up systems and networks to support DoD's global mission. There is a heightened emphasis within DoD on the use of commercial items, practices, and processes, resulting in extensive efforts to replace military and federal specifications and standards with Non-Government Standards (NGS). DoD's Standardization Program Division has established a policy encouraging the use of standards from voluntary standards bodies whenever practical and appropriate. Adoption of voluntary standards eliminates the cost to the Government of developing its own standards. The end result is a strategy for fielding systems with increased interoperability, reduced development time, increased operational capability, minimized technical obsolescence, minimal training requirements, and minimized life cycle costs.

TAFIM and JTA - The Joint Technical Architecture (JTA) and Technical Architecture Framework for Information Management (TAFIM) are both DoD guidance documents currently in effect within DoD. The TAFIM provides general guidance and documents the processes and framework for defining the JTA (and other technical architectures). The TAFIM applies to many DoD mission or domain areas and lists all adopted information technology standards that promote interoperability, portability, and

scalability. The JTA currently focuses on Command, Control, Communications, Computers and Intelligence (C4I) requirements as related to interoperability by identifying the minimum set of standards for service areas (one standard per function where possible). For the C4I service areas domain, the JTA set of standards supersedes those listed in the TAFIM.

The mandated standard in the JTA and TAFIM for document interchange is Standard Generalized Markup Language (SGML). This is an ISO approved standard for the production of documents intended for long-term storage and electronic dissemination for viewing in multiple formats. Other JTA mandated standards related to electronic data interchange include; Computer Graphics Metafile (CGM), an interchange format for vector graphics; JPEG for still picture interchange; and MPEG for video data interchange. (See Appendix A - Standards and Standards Bodies for more information about the TAFIM and JTA.)

Commercial-Off-The-Shelf (COTS) and Non-proprietary Standards and Products - Software standards to accommodate all the services and interfaces are still emerging. Although international and national standards groups have defined hundreds of information processing standards, they continue the incomplete task of defining formal standards for all functional areas needed for real-world systems.

To fill this standards gap, organizations will often have to standardize around a vendor's COTS product. Some of these products have become defacto standards or specifications. PDF and Microsoft's DOS and Windows are good examples of vendor products that have become de facto standards.

Most organizations desire the ability to purchase products based on international or national standards. This is not always possible or even desirable, since the process of becoming a standard often takes years and during that time new defacto standards based on new technology are in the marketplace. The organization then has to make the decision whether to go with a dejure standard and old technology or new technology and be at the mercy of the product vendor.

Focus Generally Operational - The JTA and the TAFIM focus primarily on the operational environment and the warfighter and do not address the disposition of records after the information is no longer required for operational reasons. The following quotations come from the JTA executive summary.

> The Joint Technical Architecture (JTA) provides the "building codes" that, when implemented, permit this flow of information in support of the Warfighter. The JTA identifies a common set of mandatory information technology standards and guidelines to for use in all new and upgraded C4I acquisitions across DoD. The JTA standards are for sending and receiving information (information transfer standards such as Internet Protocol suite), for understanding the information (information content and format standards such as data elements, or image

interpretation standards) and for processing that information. The JTA also includes a common human-computer interface and "rules" for protecting the information (i.e., information system security standards).

The scope of this initial version of the JTA is focused on Command, Control and Intelligence systems (to include sustaining base. combat support information systems, and office automation systems) and the Communications and Computers that directly support them (C4I), and the interfaces of those systems with other key assets (e.g., weapon systems, sensors, models and simulations) to support critical joint Warfighter interoperability. Future versions of the JTA will extend the Version 1.0 scope from C4I Systems to include these other domains.

Increased Need for Standards to Archive Imagery Records - Since the coverage of both dejure and defacto standards does not satisfy the needs of the record archiving community, it appears that one solution is to participate as a user in some of the standards committees. This would probably be more effective if done after the archiving community met and determined its requirements.

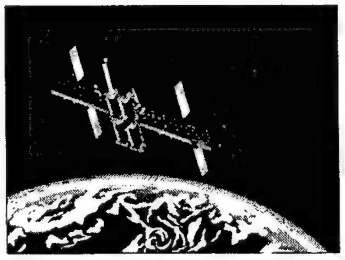
5.0 DoD and Electronic Records Storage

The Department of Defense and the National Archives and Records Administration face a difficult set of decisions on how to preserve electronic records. Because NARA directives already select ASCII and EBCDIC for text data, the greatest need is to select acceptable standards for imagery records. No standards were designed expressly for archiving, so the question now is are any imagery standards suitable for archiving? Recent DoD accessions at NARA include digital records from the Vietnam War. Prior to transfer, DoD retained these internally for a number of years. Because these data sets contain no images, they could be delivered in ASCII or EBCDIC format.

Reviewing the materials stored at NARA, by bulk most are in image format, either as still photos, audio-visual tapes, or technical drawings. For the moment this is not a problem, since the overwhelming majority of NARA accessions are non-electronic. Even the current accessions of photos are overwhelmingly film based, and not digital. The problem is the pace of change to the electronic environment.

Originals and Copies. Despite the current situation, the potential electronic input is increasing exponentially. Two types of documents are likely to surface, those originally in electronic format, and those copied into it. Those originally in electronic format include items like satellite images, geographic information systems data, digital photos, operations, personnel and medical images, and now the legacy includes manuals. Those copied into electronic formats include redacted and enhanced images. The documents originally stored in electronic format fit the traditional venue of archiving, that is saving the document in its native format or as close as practical. The latter are the result of special requirements and technology advances.

Varieties of Standards. Documents produced by the Department of Defense use a wide variety of standards. For example, in the Air Force most technical publications, including engineering drawings, are available in PDF format for access from the web. Administrative publications are available in SGML. Administrative publications generally start as documents produced in MSWord, then are placed in SGML prior to publication. For dissemination on the web they are released in PDF. Graphics in the documents are not imbedded, rather they are linked using GIF, TIFF or JPEG standards. The selection of one standard is difficult, since the production often involves several standards in a single document.



Several types of data sets offer enormous potential for research, with appropriate access. Satellite images using raster formats give researchers advantages over the old photographic images. For example, at one time cloud cover interrupting terrain in satellite photos bothered scholars. Now climatologists and others can use the imagery and by applying mathematical formulas derive valuable climatic d... from the

cloud cover itself. Also, for those wanting specific locales the ability exists to scan through these remotely sensed images and gather an incredible amount of data based on the spectral signatures or other elements.

Recent Accessions. The largest collection transferred from DoD to NARA between 1993 and 1996 was of mapping, charting and geodesy photo images from the Defense Intelligence Agency. Despite the value and resolution of aerial photography, remotely sensed digital imagery has largely displaced photo images. Digital images form a valuable database for Geographic Information Systems (GIS). The GIS needs include being able to strip out specific data from the original images. As an example, using infrared imaging scientists can select specific spectral signatures showing the reflectance of rice plants, and by applying mathematical models detect the overall health of the plants and predict crop returns. Mapping soil types, measuring snow cover and working with climatic models they forecast stream runoff, moisture, groundwater, and subsequently predict terrain passage capabilities for an armed force. Researchers and scientists value the old data for test and comparison.

Medical records have undergone significant change toward digitization. Service member medical records contain many more digital images. Physicians find MRIs and CAT scans invaluable in treating patients. Storing them, though, is a difficult mix of varied methods, rapid change, and lack of consistency in standards between different users. Physicians using the best available tools are often tied to a proprietary specification and machine, designed for immediate use, not ease of archiving.

Photographic images have changed. Some photos from the Somalia intervention were digital, and at the time viewers in the Pentagon could view a picture taken in Somalia, transmitted via satellite, downloaded, and printed in less than a half hour. While such demonstrations are impressive, the use of the digital photos remains limited. The standards used for much of the DoD photo imagery are JPEG based, and while widely accepted, its compression algorithm is lossy. That is to say it loses information permanently when compressed, making it less desirable for archiving. Newer methods being tested by Eastman Kodak and others offer more potential for the near future.

Operational Requirements. In the operational world vendor and military will continue to develop software specifically designed for individual weapons systems. The immediate demands and the lack of commercial application to many of these systems make the use of commercial-off-the-shelf products impractical. Often of unique design, they are more difficult to store. Overall this is not a major problem in many areas, for while a specific system may be quite important to a warfighter, the end product or result may not be among that three percent of items selected for preservation at the National Archives. Logistics databases are different, since they often relate to expenditures, an item of interest to many. The storage of these non-image related databases has already begun within current NARA guidelines.

How Non-NARA Archival Agencies Use Standards. A survey of agencies revealed many standards questions and few answers for archiving. For many, the real matter is providing access for the useful life of the data, while recognizing the difficulty of long term preservation. For example, the Library of Congress is using JPEG for images, but recognizes that this is not the answer for long-term preservation because of the lossy nature of the compression algorithm.[7] The Australian Archives pursues an active program to come to agreement on archiving standards, and to date have found the challenges impressive, the solutions elusive. The Canadian Archives attempted to find a standard for records management, and they deny recent tentative announcements of such a standard. In the United States, a team chaired by Don Sawyer at the National Air and Space Administration (NASA) is developing an archiving standard, but they aim more at archiving scientific databases, and less at images. This work spins from the publication *Preserving Scientific Data on Our Physical Universe*, by the National Research Council.

Within the Department of Defense the Center for Army Lessons Learned (CALL) at Fort Leavenworth, Kansas functions as a test bed for preserving materials for the Department of Defense. Using Excalibur, a commercial format, they are currently accessioning, cataloging, and preserving material; allowing information accessibility to Army and DoD sources. An ambitious project, this could be a good building block for an intermediate effort by the Department of Defense.

Digital Libraries. One intermediate solution proposed is the development of a digital library. While new archival standards and techniques develop, this would allow access to materials. Just as the Federal Records Centers provide an intermediate step for paper archives going to the Archives, the digital library could perform such a function prior to turning electronic data over to NARA. At the workshop Howard Besser enlightened on the uses of a digital library within organizations.

Mr. William Crocca of the Xerox corporation also discussed digital libraries, noting that a digital library is much more than a collection of electronic documents. To make the library useful, it must be managed to achieve a balance of access and preservation. Four key areas to consider are collection management, stewardship, navigation and access, and distribution.

- Collection management involves document acquisition (copyright permissions), collection sharing and pruning, and very long term preservation and access.
- Stewardship means running the library as a business, with an eye on cost reduction, revenue streams (contract search and delivery), and value leveraging.
- Navigation and access refers to such things as card catalog and full text search, custom anthologies, and interlibrary loans.
- Distribution means having a fair use policy, tracking royalty payments, granting rights and control, and printing and distributing documents.

6.0 SPECIFIC STANDARDS ISSUES DISCUSSED AT WORKSHOPS

To support the contractor team in gathering the information for this analysis the Department of Defense sponsored two groupware workshops. These were facilitated by the Operations Process Improvement Office (OPIO) of the Defense Information Systems Agency (DISA) on October 30-31, 1996 and March 4-6, 1997. Several objectives focused the session for a group of participants representing all the branches of the Service, several agencies, and the archival, standards, and records management communities. (For Workshop Products and Information See Appendix B) These objectives included: 1. Familiarize participants with present and future DoD imaging requirements at NARA. 2. Review the state-of-the-art electronic archiving capability. 3. Identify current standards and proposed standards for archiving electronic images. 4. Discuss the costs associated with storage and retrieval of imagery information and the relative costs associated with the imagery standards proposed. 5. Make recommendations regarding a limited set of imaging standards that will best satisfy both DoD's and NARA's major imaging needs at a manageable cost.

Achieving the Objectives. The group achieved the first three objectives, all descriptive in nature, with ease, but the latter two, involving decisions and analyzing data, were more difficult. In identifying current and proposed standards for archiving records the group set certain criteria any format must meet. Unfortunately, few existing formats could meet the desired criteria, and in follow-up work the contractor team could only identify one standard that would clearly meet the requirements of the group, a prohibitively expensive standard to implement throughout the department. Costing proved even more elusive to the group because of the difficulty associating an expense to particular standard. Certain costs were discussed and presented at the meeting and a more comprehensive collection gathered later, but they are only a generalized view, and do not equate with a sophisticated collection technique such as a functional economic analysis.

External Participants. Though Appendix B contains the list of participants, several representatives from outside of the Department of Defense who gave presentations deserve special recognition. In alphabetical order, Dr. Bruce Ambacher, National Archives and Records Administration, addressed NARA's needs. Dr. Howard Besser of the University of California, Berkeley School of Information Management and Systems addressed the issues of electronic imagery preservation and the use of digital libraries. Mr. George Carson of GSC Associates shared his background in developing standards and provided insight into how the standards developing process functions. Mr. William T. Crocca of Xerox Corporation presented information on how the private sector plans to archive digital imagery in the future. The participation of these experts assured the workshop of having added variety and of expertise in areas not readily available in the Department.

Workshop Responses

In the second workshop the group looked at the issue of image standards and discussed the needs of the Department of Defense and the group's perceptions of what would be most beneficial to NARA. These responses group into five areas: General Principles; Standards; Access; Migration Issues; and Cost.

General Principles. Under General Principles the group readily agreed that NARA and DoD must agree on the standards used in images provided to NARA. They recognized that DoD possesses a large volume of legacy documents, most of which currently reside in paper, that they need to accession to NARA. These documents will be converted into images by Executive Order and the DoD wants to submit these documents to NARA in a format agreeable with both parties. Across the image spectrum there is no "ideal" format, rather different formats for different types of images. Images do, though, come in at least four basic categories of formats that are important for archiving. These include simple raster formats (such as TIFF); Portable Composed Document Formats (such as PDF); Styled SGML (such as HTML), and SGML.

Standards. For archiving, the group preferred non-proprietary, widely implemented international standards supported by market place and conformant products. Implementation of international standards should require conformance testing to insure interoperability. International standards also may require profiling, and it may be necessary for NARA/DoD to agree on one interpretation. Also, since formats change over time, and the life cycle of such changes is five to ten years, there is a need to recognize that formats be flexible. Moreover, when information exists in several types of formats (composed, revisable, or published) then each of these formats is a candidate for archiving.

Access. Access of image records, as with other records, is important. Images should be identified and accessible (search, retrieve, and view). Where possible, metadata and other descriptive information that aids access (such as documentation, finding aids, collection guides, full text (such as ASCII representation) and indexing) will be transferred with each accession in compliance with the DoD Data Dictionary and to the extent possible, adhere to image and other information attribute convention. NARA may need to accept images in more than one type of format, depending on image use. An example of this is original documents, accompanied by redacted images; or photos accompanied by clearer enhanced photos, or even geographical information systems maps deriving material in overlays from an original.

Migration Issues. Image formats in use today will need to migrate over time. The estimated cycle time is five to ten years, but could accelerate. Migration methods should minimize the loss of information or functionality. Preserve both style and content if possible, but there may be tradeoffs between them.

Costs of Using a Particular Standard. Cost is a vital issue. DoD must justify implementation costs for each standard. Present acquisition procedures fail to account for life cycle costs such as conversion for accession, media refreshment, migration, and access to information. Without this changing the methods will continue to give an inaccurate result.

The group considered the costs of using the different standards quite important, but the data is difficult to assemble. An attempt by the Yale University Library in its Project Open Book demonstrated the difficulty. Variables change with great speed, and there is little agreement among proponents of varying views on the importance of any one item. For example, the rate at which the costs or timing of CD-ROMs, tapes, software, migration systems, or installation of new standards will go, are subject to extreme variability. Providing good statistics to build on is important. , and the utter futility to date of estimating something even ten years in the future brings many current attempts into question.

Even basic costs, such as those for publishing a page in SGML vary. The FY 1997 contract rate at the Defense Automated Printing Service is $4.75 - $7.25 per page, versus a cost of $2.75 - $4.00 per page in PDF.[8] (See Figure 7) Unanswered in the current cost is what the usefulness of these formats will be tomorrow, how the costs will change, or how accessing systems will vary. Cost remains a critical, but difficult area to assess, even with a formal data call.

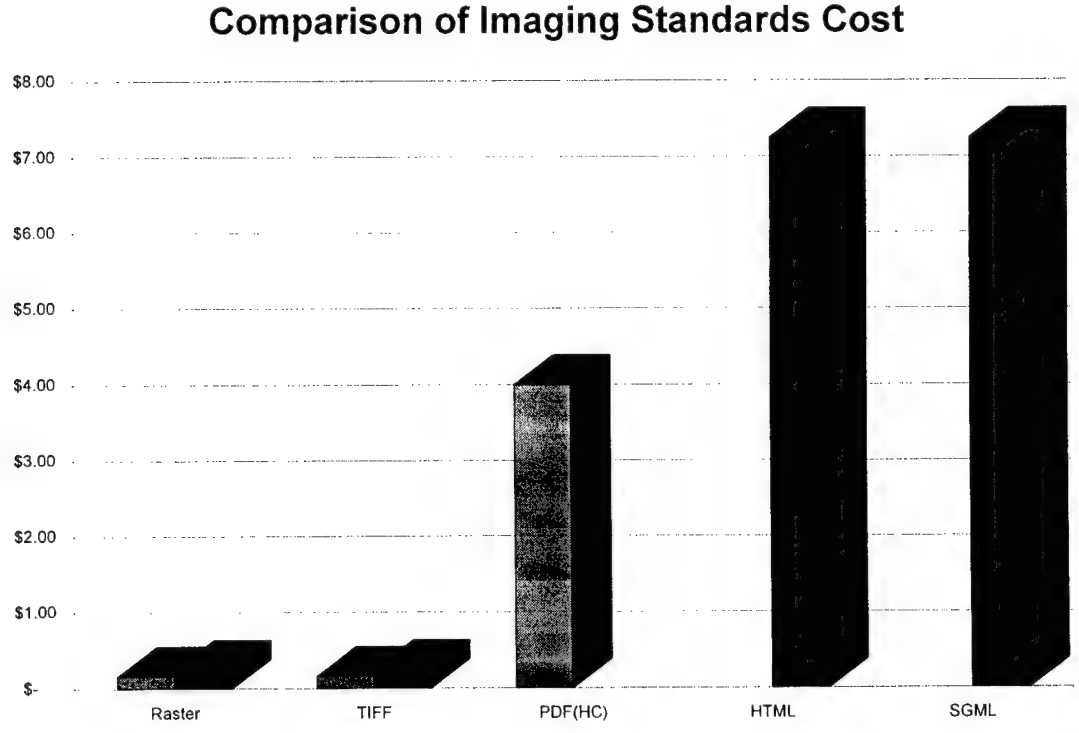


Figure 7: Comparison of Imaging Standards Cost Source: Defense Automated Printing Service

The Department of Defense produces, stores, and seeks access to large quantities of information. A Defense Automated Printing Service project converting DoD Specifications and Standards involved 600,000 pages to SGML and 700,000 pages to indexed raster files. An Air Force conversion of Technical Orders to SGML was 200,000 pages. The Navy converted to indexed raster 12,600,000 pages of Technical Manuals. For its Technical Manuals the Army opted for a PDF format for 1,000,000 pages. The engineering drawings converted to raster format involved 4,100,000 pages from the Defense Logistics Agency and 13,855,000 pages from the Navy. Army Archives sent 200,000 pages for indexed raster conversion. These are only a small sampling of the items being stored in electronic format within the Department of Defense.[9]

Consider the Defense Finance and Accounting Service projections. They will have 1,500,000 contracts a year with up to 700 pages per contract. They need to save for a scheduled period of time an annual production of 300,000 personal property government bills of lading (GBL), 1,600,000 freight GBLs, and 40,000,000 vouchers. As the systems shift to an electronic system, the method(s) and cost of preserving the contractual information become more difficult to determine.[10]

Imagery Standards

These considerations came from an extensive discussion of potential standards used in the Department of Defense and the possibility of using them for archiving image records. One of the discussion items was the type of standards used and how they meet the requirements sought. A number of standards were presented and later cut to a short list of those that met criteria established by the workshop group.

While a true document management system can handle any file in its native format, there are situations where one file format is best for archiving. Considerations for selecting file formats include file size, image quality, and whether the files need to be black and white or color, 3-D or 2-D, or editable or read-only. There are many formats to choose from when archiving. Raster and vector formats that follow illustrate some of the choices available. These formats are in order according to DoD policy with JTA mandated standards first, TAFIM adopted standards next, and other standards third if no mandated or adopted standards are available.

Raster

JPEG. Joint Photographic Experts Group (JPEG) is a standard color compression file format mandated by the JTA and TAFIM. It is the most used color compression format, supported by most Web browsers and used on many networks. Users of JPEG must decide whether to use the progressive, sequential, baseline, or lossless format. In addition, compression to JPEG loses some color information, though a color compression toolkit can recalibrate the image and correct the exposure. Because of the popularity of JPEG, it is a fairly safe choice for long-term storage.

CALS. Continuous Acquisition and Lifecycle Support (CALS) compression is a standardized, black and white, raster format. It is adopted by the TAFIM, but not mandated by the JTA. Future versions of the JTA expect to address engineering and technical data standards such as CALS. Owned by the CALS Management Support Office of the U.S. Department of Defense, this file type used by the military probably have long term viability. CALS uses CCITT III and IV compression.

GIF. The Graphics Interchange Format (GIF) is an extremely stable, lossless color format that is fully backwards compatible. (Lossless compressed images retain their integrity down to the pixel. Lossy compressed images use a difference algorithm that drops some image integrity.) Designed for color, GIF is an 8-bit format where each pixel represents one of 256 colors. Because of this, converting files to grayscale does not lower the file size. GIF is best for lower resolution files where there are large areas of like-colored pixels. Although widely used, it is not mandated by the JTA or TAFIM because it contains a patented algorithm for which the patent holder is charging royalties. JPEG provides a publicly held and viable alternative with strong marketplace support.

TIFF. Originally created in 1986, the flexible Tag Image File Format (TIFF) has become a widely used de facto specification. Unfortunately, TIFF is so flexible in allowing designers to create their own tags that not all applications can read all TIFF files. In addition, TIFF files may compress using one of several different compression formats (including JPEG compression and CCITT Group III and IV) or they may remain uncompressed. Not approved by a recognized standards body, TIFF is not included in the JTA or TAFIM. It is, however widely used in DoD component publications, and is planned as the basis for the scanning and redaction of one billion pages of classified documents. NARA also uses it for access to documents on the internet, but not for preservation. Even on the matter of using TIFF, NARA uses version 4 and DoD uses version 6 for the internet, and the two are not interchangeable.

Vector

SGML. Standard Generalized Markup Language is a formal standard defined by ISO/IEC 8879, FIPS 152, and MIL-M-28001B. SGML is a meta-language that allows users to define, in machine-readable form, the structure and content of any class of documents. The standard specifies a method for creating document hierarchy models in which every element in a document fits into a logical, predictable structure.

SGML is able to separate the logical and physical structure of text. In this way, the standard is able to distinguish between the role of piece of text (e.g., caption, title, chapter, index) and its appearance (e.g., type face, font, size, margin). This permits text to be tagged with descriptive markup, enhancing its functionality. By providing the ability to associate processing instructions with document markup, SGML includes a mechanism for referencing non-text forms within a document. By providing tags that enable query and hypertext capabilities, SGML is a standard that allows the production of intelligent documents for distribution and use on CD-ROM and other random access

media. The SGML standard is useful to organizations that exchange information between systems, applications, departments, and users.

CGM. Computer Graphics Metafile (CGM) is a standard color file format, primarily oriented towards stroke-drawn graphics, such as polylines and filled polygons, though it also supports raster bitmap encodings. CGM may or may not be compressed. It became an international standard in 1987 and is the national standard for many countries, including the U.S. and U.K. The U.S. Department of Defense adopted CGM for their major CALS open documentation initiative. The JTA and TAFIM mandate use of CGM. Since the CGM format is very complex, all applications may not support all entities.

IGES. The Initial Graphic Exchange Specification (IGES) format was designed as an exchange format. Used primarily for 3-D images, IGES files tend to occupy a great deal of storage space. IGES selection derives from its independence from any application and its support by many high-end CAD and modeling programs. Like the DXF format, IGES bridges the gap across applications, allowing users to save a CAD file as IGES, then load it directly into a graphics or 3-D modeling application. CALS also supports IGES.

Products can convert IGES files to Computer Graphics Metafiles (CGM). IGES is used primarily in the mechanical CAD sector, whereas CGM has propagated itself across the board into diverse sectors including mechanical and electrical CAD, geophysical exploration, GIS, desktop publishing, and presentation graphics. This means that IGES files can convert to CGMs for importation into any publishing system or produced as hard copies outside the CAD system.

In 1996, IGES was revised and redesignated as Digital Representation for Communication of Product Definition Data (ANS/USPRO/IPO 100-1996). Adopted by the TAFIM, it is not included in the JTA.

STEP. Standard for the Exchange of Product Model Data (ISO 10303) provides a representation of product information along with the necessary mechanisms and definitions to enable product data to be exchanged. The exchange is among different computer systems and environments associated with the complete product lifecycle including design, manufacture, utilization, maintenance, and disposal.

The overall objective of STEP is to provide a mechanism that is capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product data bases and archiving. In the long term, STEP will probably replace IGES because it covers the entire product lifecycle. A strategy to migrate from IGES to STEP is being developed by the IGES/PDES (Product Data Exchange Specification) Organization. Adopted by the TAFIM, STEP is not included in the JTA.

PDF. A direct subset of PostScript, the Portable Document Format (PDF) is more compact and has a faster processing time. It also has some capability for hyperlinking and is supported by more applications than PostScript. Generally used for textual information only, PDF files can support graphics. PDF uses a page definition language, as opposed to image definition, making the files bulky. As with PostScript files, PDF files are not editable. The JTA mandates that all organizations be capable of reading and printing documents in PDF format.

HTML. HyperText Markup Language. HTML is an informal Internet standard defined by RFC 1866. HTML consists of a set of tags that conform to SGML rules and conventions. The HTML tag set can be used as the basis to define a DTD (Data-Type Definition) that is consistent with SGML syntax. By defining HTML in an SGML DTD, HTML becomes an SGML application.

The HTML document type contains relatively general semantics for representing information for linking of data and document with a limited SGML tag set and limited formatted capability. Moreover, simplicity was the guide in development so that multiple browsers and editors could be used on multiple platforms. The following list gives some idea of the specific uses available: hypertext news, mail, on-line documentation, menus of options, database query results, and simply structured documents with in-line graphics. HTML has the capability to allow networked hypertext to use text, sound, movie, and images in a variety of formats.

DXF. Data Exchange Format (DXF) is a color, proprietary format of Autodesk. It is supported by most CAD-based and 3-D graphics programs and has become a standard, but after years of development, old formats may or may not be supported. One of its current uses is to bridge the gap from one application to another. For example, a file can be saved as a DXF in AutoCAD, then loaded in 3-D Studio or another graphics program. As an ASCII-based format, DXF files tend to be bulky.

HPGL. Developed for pen vector plotters, Hewlett Packard Graphics Language (HPGL) files are a vector-based system of lines. They save time because many printers and plotters can read them directly, meaning you can copy them to the printer or plotter without loading them into an application first. HPGL/2 files are a binary representation of HPGL with new commands making it faster and more compressed than HPGL. HPGL/2 files can also have TIFF files embedded.

PostScript. PostScript files are bulky but they are an industry standard. These uneditable files present a time-saving alternative to scanning documents, and like HPGL files, any PostScript printers can receive Post Script files directly. Unfortunately, not many applications can directly import PostScript files.

Neither the JTA nor the TAFIM includes DXF, HPGL, and PostScript formats.

Other

There are other vector formats, such as DWG, ME10, and CADKey, but these are proprietary and may be more likely to change or be discontinued. If choosing a proprietary file format, an agency may want to archive to native application to assure the ability to view and edit the files, even if the application becomes obsolete or discontinued. This will also ensure that there is no conversion loss from translation.

Another alternative is to use a viewing application. Viewing applications load many different file formats including older formats, and often include other features such as redlining capability and ISO 9000 compliance banners. Many of these applications can integrate with a database or document management software for fast file access.

Table 2. Characteristics of Selected Image Formats

FILE FORMAT	RASTER	VECTOR	3-D	COLOR	EDITABLE*	COMPRESSED/ UNCOMPRESSED	PROPRIETARY
CADKey		X	X	X	X	Uncompressed	X
CALS	X				X	Compressed	
CGM	Rarely	X		X	X	Either	
DWG		X	X	X	X	Uncompressed	X
DXF		X	X	X	X	Uncompressed	X
GIF	X			X	X	Compressed	
HPGL		X			X	Uncompressed	
IGES		X	X	X	X	Uncompressed	
JPEG	X			X	X	Compressed	
ME10		X	X	X	X	Either	X
PDF		X		X		Uncompressed	
PostScript		X		X		Uncompressed	
TIFF	X			X	X	Either	

Compression is also a key factor in archiving. Users may want to zip files to attain maximum storage capability in their archiving system. Though there are several compression packages available, PKZIP, the standard for nearly a decade, is consistently backwards compatible. Some formats, such as GIF and JPEG, are already compressed, but most vector formats are not. To archive thousands of files, however, compressing each one can be a time-consuming and costly process.

What are Some Future Standards?

SPIFF. Still Picture Interchange File Format. SPIFF is the "official" JPEG file format. Part 3 of the JPEG standard (ISO 10918) now includes a fully defined file format for

storing JPEG data. When the JPEG format standardized, disagreements among ISO committees prevented creation of a standard JPEG file format. The defacto format that appeared was JFIF from C-cube Microsystems. The JFIF format, although now quite wide-spread, is very limited in capability as file formats go. JFIF is currently mandated by the JTA.

SPIFF is intended to replace the JFIF file format, adding features (more colorspaces, a recognized way of including text blocks, and so forth), and providing a backwards-compatibility allowing SPIFF files to be read by most JPEG/JFIF decoders. JFIF, however, has a five-year head start on SPIFF, so the likelihood of a rapid replacement is not good.

FlashPix. Designed by a consortium of Kodak, Hewlett Packard, Live Picture, and Adobe, FlashPix is planned to replace Photoshop 5.0. It contains a robust set of metadata tags and may become a new de facto specification because of the influence of the developers.

Xerox Information. Xerox Corporation has studied some of the problems of document storage and Mr. William Crocca presented some information on Digital Libraries and possible future directions. Possible future directions as seen by Xerox involve a mix of developments in hardware and software technology. Some key points made by Mr. Crocca were:

- Leverage on-going research in electronic archiving
- Disciplined adoption of newer storage media
- More integration with transaction systems
- Richer linguistic tools that allow better navigation for patron-sought concepts
- Knowledge management to provide richer yet more focused searching and focused data delivery
- Incorporation of optical search/pattern recognition such as in graphics and photographs

Classes of Imagery Standards

Standards and specifications can be identified by their roles in the document life-cycle. One way of describing these roles is to use the four main standards categories of content, structure, presentation, and distribution. This provides a framework for discussing standards and products by specific functional areas.

Contents Standards Contents Standards relate to data representation and include CGM as the vector graphic data interchange standard, IGES as the Product Data Exchange Standard, and ASCII as the character set standard.

Structure Standards Structure Standards describe how rules for document organization should be specified. SGML is the Document Type Custom Definition Standard, which specifies the way to use a Document Type Definition (DTD) to represent the dependence

between document components. Standard for the Exchange of Product Model Data (STEP) is another Product Data Exchange Standard. TIFF is an informal standard that falls into the structure class.

Presentation Standards Presentation standards ensure that similar structure contents are represented in similar ways, regardless of the implementation approach. The most commonly used presentation standard is PDF which allows the display of documents in their original format. PDF is currently proposed as a standard for the delivery and presentation of non-revisable documents.

Distribution Standards Distribution standards are links between applications, enabling documents to be packaged and exchanged between applications during their life cycle. Distribution standards involve media as well as format, such as Optical Digital Technology Standard for CD-ROM.

Another way of classifying imaging standards is to put them on a sliding scale from static to dynamic based on the amount of change the corresponding document can undergo. The following diagram, presented at the workshop by Steve Carson, shows various document types and related standards.

Table 3. Document Types and Related Standards

Document Type	Page	Raster	PCDF	Word Processor	Styled SGML	SGML
Standard or Product	ASCII, EBCDIC	TIFF	PDF, Envoy	MS Word WordPerfect	HTML	SGML

Not Revisable <----------> Revisable
Final Form

For archiving purposes, documents transmitted in ASCII or EBCDIC retain the original data but the page layout format is lost. TIFF and PDF also retain the original data but carry the formatting codes forward. MS Word, WordPerfect, HTML, and SGML are revisable formats and are able to include images and formatting. The four key products/standards for electronic imaging are TIFF, PCDF, Styled SGML and SGML.

Considerations for the Future. Looking to the future the group session revealed a number of concerns. Most group into one of three categories, determine what can be or was done; determine the format; and recommend policy changes.

Estimate Volume and Format of Imagery Records. To find what can and has been done, group members recommended follow-up research. This would include determining costs of using each standard; survey DoD organizations to determine volume and formats of documents. Conduct a data call to gather specific raw data about the prioritized list of image types such as legacy documents, and engineering drawings. The call should

include better figures about volume and standards or formats, including the uniformity of image applications used throughout DoD. The value of the data call would provide a validity and reliability check on intuitive conclusions.

To determine the format group members presented several ideas. They included application of principles considered earlier in this chapter be applied and use of a team of subject matter experts in standards to determine the proper standards to use. Researchers would determine the extent of the universe for various types of images. They would identify requirements including new profiles, standards, conformance testing and certification efforts, test suite generation and promulgation efforts, and joint industry and government initiatives.

Determine Cost of Using Various Imagery Standards. Recommending policy changes, members suggested that based on DoD's requirements, determine the appropriate electronic image standards to recommend for NARA and DoD's use, and charter a trial implementation effort. When NARA and DoD reach agreement on acceptance of image standards to use, the principles suggested by the group should form the basis for determining the costs, including access and migration, and applied to NARA and DoD. They should determine and cost probable migration methods and prepare documents for inclusion in the budget to fund these future migrations. Following this DoD should charter a trial implementation effort. Following adoption of the image standards, current directives such as the JTA, TAFIM, and DoD 5015.2 Records Management Policy, will need updating or revision as required. As technology advances, review the imagery policies and standards and update on a periodic basis.

7.0 RECOMMENDATIONS

The group workshops and the contractor team between them came up with several recommendations, grouped in three areas. First, what standards should NARA and DoD adopt? Second, what imagery standards bodies or industry affinity groups should DoD participate with to assure input in the criteria for those standards or specifications? Third, what directions would most benefit DoD and the National Archives in achieving the goals of preserving imagery and information while providing greater access.

Image Standards That NARA and DoD Should Adopt.

Recommendation 1: Adopt SGML as an archiving standard at DoD and NARA, with certain caveats.

Recommendation 2: Have a team of subject matter experts continue evaluating other imaging standards, including proprietary systems.

The second workshop did not make a clear standard(s) selection at its meeting, rather it selected criteria to meet. Early in the process the group recognized the problems of using every standard for archiving. Among the hundreds of standards most simply do not have broad enough usage to justify the cost and effort, at this time, of preserving them. After a thorough review of the image standard(s) criteria needed for selection as an archiving standard, the contractor team concluded that only a handful could make the "short list." These included JPEG, JFIF, TIFF, PDF, HTML, and SGML. One standard, SGML, met the rigorous requirements more than any other, and it only with caveats. Some that did not meet all requirements in the tentative listing were retained for future review because of the difficulty of measuring certain parts of the criteria, such as costing, at this time. Also, changing views in the federal government on the use of proprietary systems may alter the view on their use.

Recognizing that there is no one "ideal" format for all archiving of publications, the workshop members proposed certain criteria for evaluating use of standards in archiving:

- Standards selected should be widely implemented international standards supported by the marketplace and conformant products
- Where possible, avoid proprietary products
- International standards may require profiling
- When a document exists in multiple formats, consider each for archiving
- Standard allows migration with minimal loss of information or functionality
- Preserve style and content where possible
- Justify cost
- Costs should include entire life-cycle, including conversion for accession, media refreshment, migration, and access to information.
- Standard must contain metadata that support cataloging and accessing

- Desire mature standard, one around long enough to ensure its acceptance and to assure that many will promote its migration to new systems
- Standard should be stable, with few major changes in recent years

Table 4: Standards Relationships Addressed at Workshop

Standard	Standards Body	DoD Repre-sented	Cost per page (DAPS)	Propri-etary	Widely Used	ISO Spec	Stable	JTA - J TAFIM - T Neither-N
ASCII	ISO	Y	N/A	N	Y	Y	Y	J
TIFF	Microsoft	Y	N/A	Y	Y	N	Y	N
PDF	Adobe	N/A	$2.75	Y	Y	N	Y	J
MS Word/ WordPerfect	Microsoft/ Novell	N/A	N/A	Y	Y	N	Y	J
HTML	IAB	Y	N/A	N	Y	N	Y	J
SGML	ISO	Y	$4.75-$7.25	N	Y	Y	Y	J
JPEG/JFIF	ISO	Y	N/A	N	Y	Y	Y	J
---	---	---	---	---	---	---	---	---
Raster OCR/SCR/ Photo Scan	(pricing only)		$0.16 $1.80					

SGML is the image standard recommended for adoption by NARA and DoD. Since many DoD agencies already use SGML for setting up records, agencies with operational documents or their own archival records in SGML should be allowed to transfer material to NARA in SGML format. The caveat is that other organizations that do not have records stored in SGML should not have to store them in this way because of the cost of SGML. FY 1997 costs for transferring a document to SGML format by the Defense Automated Printing Service are $4.75-$7.25 per page. Other methods, such as PDF, at $2.75 per page are far more cost effective than SGML, but they fail to meet archiving criteria on other counts. The following table summarizes this recommendation of SGML.

Table 5. SGML Characteristics

Specification Title	Standard Generalised Mark-up Language (SGML), ISO 8879:1986
Applicability	SGML is a mark-up language for defining the logical structure of documents. SGML is capable of supporting the integration of text, graphics and scanned images. SGML permits breaking a document into parts storable in several files. It is characterised by its content (logical structure) and its internal organisation (layout structure) derived from a formal type by means of a Document Type Definition (DTD).

Level of Consensus	SGML is an ISO standard adopted by the ISO organisation and the CALS program.
Maturity	The concepts for SGML are mature
Stability	Within the current ISO 5 year review process, minor changes to SGML are expected but they will be compatible with the existing standard
Product Availability	Many SGML products are available, but are not all conformant nor interoperable
Conformance Testing	SGML products are, now certified only by the US to ANSI X3.190-1993 Standard, but being adopted as an ISO standard. The Conformance Testing for SGML Systems (under development by ISO fast track from ANSI X3.190-1993) is ISO/ICE DIS 13673:1994.

The group also recommended that the evaluation of existing standards using the workshop criteria. Table 4 depicts results of a preliminary study. The need is for a more accurate study, particularly in the areas of cost and of viability to the National Archives.

The next stage would be to assemble a team of experts to include new profiles, standards, conformance testing and certification efforts, test suite generation and promulgation efforts, and joint industry and government initiatives.

As technology advances, review the imagery policies and standards and update them on a periodic basis. This would require a group to monitor the program.

Imagery Standards Bodies With Whom DoD and NARA Should Participate

Recommendation 3: DoD should retain representation on standards bodies and seek an advisory role in proprietary systems that significantly affect DoD.

OMB Circular A-119 Federal Participation in the Development and Use of Voluntary Standards. This Circular establishes policy for executive agencies in working with voluntary standards bodies. It also establishes policy for executive branch agencies in adopting and using voluntary standards. In short, this circular recommends that agencies adopt voluntary, international standards based on performance criteria whenever possible. It also encourages participation by Federal agency employees in voluntary standards bodies and standards-developing groups. Agency rep: ntatives

should participate actively, on a basis of equality with private sector representatives and not seek to dominate such groups.

Recognizing this need, the contractor team reviewed the current DoD participation in standards efforts. In short, the team determined that the Department should retain its affiliation with formal standards organizations. A suggested change is that where feasible, DoD should, as a prudent customer, work with developers of commercial standards to develop de facto specifications that incorporate the Department's needs.

First, the principal standards organizations in the United States. IGES/PDES Organization (IPO) of US PRO is the representative body of individuals that develops standards for product data exchange (PDE) technology. Working in cooperation with the ISO through its U.S. Technical Advisory Group (TAG), the IPO is also the U.S. representative for the development of the international standard STEP. The American National Standards Institute (ANSI) accredited the IPO as the U.S. organization to develop standards and specifications for the sharing and exchange of product information.

Currently DoD participates in the major international and national imagery standards bodies. The following table summarizes these efforts:

Table 6. Standards Bodies and DoD Representatives

Standards Body	**DoD Representative**
International(ISO)	
JTC 1 SC 24 TAG (Computer Graphics & Image Processing)	Dr. Doris Bernardini
JTC 1 SC 29 WG 11(Coding Audio, Picture, Multimedia & Hypermedia)	Dr. Doris Bernardini
National(ANSI)	
Technical Committee X3H3(Computer Graphics & Image Processing)	Dr. Doris Bernardini
Technical Committee X3L1(Coding Audio, Picture, Multimedia & Hypermedia	Dr. Doris Bernardini
Task Group X3H3.8(Image Processing and Interchange)	LCdr Mike Morris

NARA and DoD records managers should meet with the DoD representatives to the national and international standards bodies listed above to develop requirements and a strategy for participation in these standards bodies. Appendix H is a complete list of DoD representatives to International, National and Federal Standards Bodies.

Table 7. Standards Bodies and Represented Standards

Standards Body-International(ISO)	Standards
JTC 1 SC 2 Coded Character Sets	ASCII
JTC1 SC 18 Document Processing and Related Communication	SGML
JTC 1 SC 24 TAG (Computer Graphics & Image Processing)	JPEG
JTC 1 SC 29 WG 11(Coding Audio, Picture, Multimedia & Hypermedia)	MPEG

The Department of Defense should consider changing policy to allow participation in the development of "de facto standards or specifications." The Department is requesting that members seek commercial-off-the-shelf solutions and this necessitates working with the developers of proprietary systems. This would require a change in direction, and would require DoD to contact organizations such as Adobe, the manufacturer of PDF, or the consortium developing FlashPix. To date, the commercial sector has created most of its products without formal input by DoD.

New Directions That Benefit DoD and NARA.

The workshop groups identified several areas that need further study by the Department of Defense. These concerned costs, gathering of information, and specific changes needed to facilitate the preservation of and access to digitized records.

Recommendation 4: Determine the life cycle costs of all potential imaging standards options so they can be used in budget planning.

The group recommended that the life cycle costs of each potential standard be determined, with these figures used in budget planning. Probable future migration and access methods should be applied to the costs to both NARA and DoD. Documents for inclusion in future budget initiatives should be included. Gathering and creating accurate and effective data is difficult, since much of the future of electronic data is uncertain. Yale University's Project Open Book attempted to look at some costs, and the authors acknowledged this near impossible, but necessary, aspect of budget planning.

Recommendation 5: Conduct a data call to determine the standards and quantity of images used across DoD.

The group recommended a formal data call to determine with greater accuracy the present and future volume and formats of images. The result would give greater precision in budget planning. Such a listing does not exist and would help in determining the present use of image standards and a properly conducted data call would allow a determination of the direction of future electronic imaging.

Recommendation 6: Evaluate the need for a DoD digital library as an intermediate step toward archiving and as a means of coordinating ongoing digital library and repository programs.

The last item covered by the group was the possibility of a digital library or other intermediate step allowing access to data prior to archiving. This comes from the concern over how to provide for the needs of the Services and Agencies while providing for NARA's needs. The suggestion goes back to Figure 3 on page 5, where there is a clear sequence of activities taking non-electronic records from the Department to Federal Records Centers where they reside for the duration of their schedule. They are then retired or moved to NARA. In the case of Electronic Records, the movement is simply from DoD to NARA. (See Figure 7) A much more sensible approach would be to move the digital records from DoD into a digital library. Several Services and Agencies have already started doing this, and without coordination, their efforts may lead to non standardized, stovepipe systems. A DoD wide oversight organization could set up a method that would allow for standardization, and could forward on records within a NARA acceptable format to meet preservation criteria. There would be no need to stop any departmental effort, rather adjust it to assure standardization.

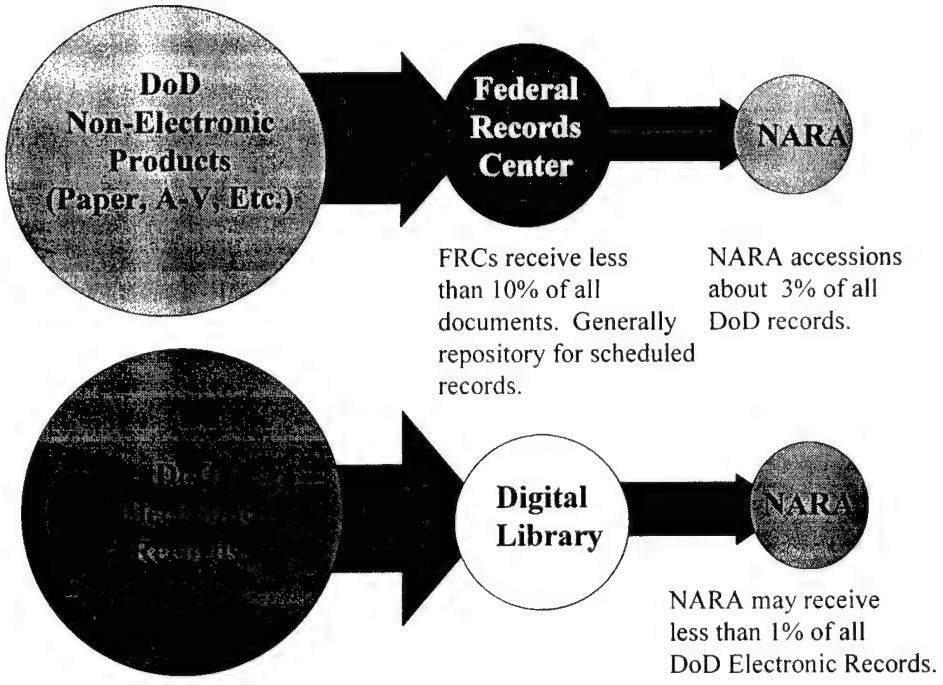


Figure 7. Proposed Flow of Information to NARA

8.0 CONCLUSION

The purpose of this report was to conduct a requirements analysis for electronic records recording formats that will lead to the selection of alternative standards for the storage and retrieval of electronic records and the information they contain. Using two workshops as the basis for the source material, the study reflects the considerable progress made in that direction. Criteria were applied, some solutions found, and directions to follow to resolve the remainder established.

Specifically, Image Standards Agencies the Department of Defense should participate with are identified. Additionally, DoD is advised to pursue relationships with commercial producers. As more products are purchased commercial-off-the-shelf, the Department should, as a customer, work with its providers. This means contacting organizations such as Adobe to explain how DoD might benefit from improvements to PDF, or deal with the consortium developing FlashPix, to share needs before the specifications are complete.

The selection criteria established by the group narrowed the assemblage of standards to consider to less than a dozen. None of this dozen were immediately eliminated from consideration, because they need further research. One, SGML, should be accepted by the National Archives and the Department. The caveat is that DoD organizations now using SGML should be allowed to preserve and deliver to NARA their data in this format. The high cost of taking documents into this format makes it ineffective as a device for storing all archives. For example, storing the one billion pages subject to imaging and redaction in an ongoing declassification effort could cost as much as $4,750,000,000, an impossible figure to justify in the budget.

To complete this study, the department needs to

- Determine the life cycle costs of using each potential standard and plan methods for the inclusion of this figure in the DoD budget.
- Survey organizations to determine volume and formats of images
- Assemble a team of experts to include new profiles, standards, conformance testing and certification efforts, test suite generation and promulgation efforts, and joint industry and government initiatives.
- Complete the evaluation of existing standards using the workshop criteria
- Update and revise affected DoD publications as required
- As technology advances, review the imagery policies and standards and update on a periodic basis
- Evaluate the need for a DoD digital library allowing access to and less costly preservation of data prior to archiving with NARA

Taking this project to its next logical steps will provide DoD with a way to follow the instructions of archiving laws while offering greater access to digital information.

ACRONYMS

A-V - Audio-Visual
ANSI - American National Standards Institute
ASCII - American Standard Code for Information Interchange
C4I - Command, Control, Communications, Computers and Intelligence
CAD - Computer Aided Design
CALL - Center for Army Lessons Learned
CALS - Continuous Acquisition and Lifecycle Support
CAT - Computerized Axial Tomography
CD-ROM - Computer Disc - Read Only Memory
CGM - Computer Graphics Metafile
COTS - Commercial-Off-The-Shelf
DAPS - Defense Automated Printing Service
DIA - Defense Intelligence Agency
DISA - Defense Information Services Agency
DoD - Department of Defense
DTD - Document Type Definition
DWG - An AutoCAD two-dimensional Drawing file format
DXF - Data Exchange Format
EBCDIC - Extended Binary Coded Decimal Interchange Code
EKG - Electrocardiogram
FRC - Federal Records Center
GIF - Graphics Interchange Format
GIS - Geographical Information System
HPGL - Hewlett Packard Graphics Language
HTML - Hypertext Mark-Up Language
IAB - Internet Architecture Board
IEEE - Institute for Electrical and Electronic Engineers
IETF - Internet Engineering Task Force
IGES - Initial Graphic Exchange Specification
IPO - IGES/PDES Organization
ISO - International Organization for Standardization
ISOC - Internet Society
ITU - International Telecommunication Union
J-STARS - Joint Surveillance Target Attack Radar System
JBIG - Joint Bi-Level Imaging Group
JFIF - JPEG File Interchange Format
JPEG - Joint Photographic Experts Group
JTA - Joint Technical Architecture
ME10 - Two-dimensional CAD product from Hewlett-Packard
MPEG - Motion Picture Experts Group
MRI - Magnetic Resonance Indicator
NARA - National Archives and Records Administration

NASA - National Air and Space Administration
NIMA - National Imagery and Mapping Agency
OMB - Office of Management and Budget
OPIO - Operational Process Improvement Office
PDE - Product Data Exchange
PDES - Product Data Exchange Specification
PDF - Portable Document Format
PKZIP - Commercial compression/decompression product
SGML - Standard Generalised Mark-up Language
SPIFF - Still Picture Interchange File Format
STEP - Standard for the Exchange of Product Model Data
TAFIM - Technical Architecture Framework for Information Management
TIFF - Tagged Image File Format
US PRO - United States Product Data Association
VHS - Standard format for video cassette recorders

List of Workshop Participants

Two facilitated groupware supported workshops, held on October 30-31, 1996 and March 4-6, 1997 aided in gathering information for this research.

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ENDNOTES

[1] "Long-Term Management Issues in the Preservation of Electronic Information," paper presented by Maggie Exon, School of Information and Library Studies, Curtin University of Technology at the 2nd National Preservation Office Conference: Multimedia Preservation - Capturing the Rainbow, in Brisbane, Australia, 28-30 November 1995.

[2] Internet document "What is the National Archives," a web page maintained by the National Archives. Access point as of 2/26/97 was http://www.nara.gov/nara/whatis/records.html.

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[8] e-mail from Defense Automated Printing Service, subject Document Conversion Pricing, dated April 10, 1997, and information provided by Michelle Spiro on April 29, 1997.

[9] From "Document Services Offered by Defense Automated Printing Service" an undated Defense Automated Printing Service slide presentation provided by Michelle Spiro.

[10] Ibid.